

**Table 2: Notes on Mars Local Link Frequencies Recommended in Table 1**

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General Comments:								
1. All present and planned future missions to Mars use X-Band S-to-E and E-to-S links.								
2. A few missions also carry S-Band S-to-E or E-to-S links. The S-Band uplink is restricted by IMT2000.								
3. For all frequencies on this table, technology or equipment is available in the industry.								
4. Saturation or jamming refers to strong interfering signal overwhelming the receiver operating in the same band or adjacent band. For missions at Mars saturation happens only on the same vehicle, not likely between vehicles because of the large distance between them.								
5. Cross interference refers to interference from one vehicle to another. For Mars missions, such interference is not likely to occur in the adjacent band.								
	Data Rate Performance	Accurate Antenna Pointing for Performance	Mass and Volume	Possible Equipment Sharing with Deep Space Space-Earth Links	Self-Interference with Deep Space Space-Earth Links	Cross Interference with Deep Space Space-Earth Links	Testing with Signals Transmitted from an Earth Station	Comments
<b>1.0 Space-to-Earth (S-to-E)</b>								Per ITU-R RR
<b>2.0 Earth-to-Space (E-to-S)</b>								Per ITU-R RR
<b>3.0 Orbit-to-Surface (Command)</b>								
3.1 435-450 MHz	Best at low rate, with LGA	Not required with LGA	large	none	none	none	Only on non-interfering basis (NIB)	For low rate links
3.2 2025-2110 MHz	High rate, with MGA/HGA	Required with small beamwidth (A)	small	If the lander carries an S-Band E-S receiver (Note: Deep space E-to-S is restricted by IMT2000) it is possible to modify the receiver to operate at extended frequencies.	If the orbiter carries S-Band E-S, the S-Band local link transmitter could saturate the S-Band E-S receiver unless there is adequate isolation.	none	Coordination is easier, as the band is allocated to SRS E-S, near Earth, where similar transmissions operate, although at lower power.	For high rate links. Can't share X-Band equipment.
3.3 7190-7235 MHz	Higher rate, with HGA	Required with smaller beamwidth (1/4 A)	smaller	Possible to modify the X-Band E-to-S receiver to operate at extended frequencies.	The orbiter X-Band local link transmitter could saturate an orbiter X-Band E-S receiver unless there is adequate isolation.	none	High power transmission in urban area is restricted to protect fixed and mobile services. A lesser problem in rural areas.	For high rate links. Can share X-Band equipment. Must avoid self-interference to the X-Band E-to-S link

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3.4 14.5-15.35 GHz	Even higher rate than X-Band, with HGA	Required with even smaller angle (1/8 A)	even smaller than X-Band	none	none	none	NIB	For high rate links
<b>4.0 Surface-to-Orbit (Telemetry)</b>								
4.1 390-405 MHz	see 3.1	see 3.1	see 3.1	none	none	none	NIB	For low rate links
4.2 2200-2290 MHz	see 3.2	see 3.2	see 3.2	If the lander carries S-Band S-E transmitter (2290-2300 MHz), it is possible to modify the transmitter to operate at extended frequencies.	An orbiter S-Band S-to-E transmitter could saturate the orbiter local link receiver unless there is adequate isolation.	none	NIB	For high rate links. Not as good as 4.4 which allows X-Band equipment sharing.
4.3 2290-2300 MHz	see 3.2	see 3.2	see 3.2	If the lander carries S-Band S-to-E transmitter, the local link can share the transmitter without modification.	An orbiter S-Band S-E link transmitter will saturate the orbiter S-Band local link receiver.	An orbiter with S-Band S-to-E link could interfere with the local link receiver if the latter is in its antenna beam.	NIB	For high rate links. Not as good as 4.4 which allows X-Band equipment sharing.
4.4 8400-8450 MHz	see 3.3	see 3.3	see 3.3	Can share without modification a lander X-Band S-to-E transmitter.	An orbiter X-Band S-E link transmitter will saturate the orbiter X-Band local link receiver.	An orbiter with X-Band S-to-E link could interfere with another orbiter receiving local X-Band link if the latter is near or in its antenna beam.	NIB	For high rate links. Must avoid cross-link interference from S-E links.
4.5 8450-8500 MHz	see 3.3	see 3.3	see 3.3	Possible to share a lander X-Band S-to-E transmitter modified to operate at extended frequencies.	Orbiter X-Band S-to-E transmitter could saturate the orbiter local link receiver unless there is adequate isolation.	none	NIB	For high rate links
4.6 16.6-17.1 GHz	see 3.4	see 3.4	see 3.4	none	none	none	Already allocated to SRS, deep space, E-to-S, secondary	For higher rate links
<b>5.0 Surface-to-Surface</b>								
5.1 435-450 MHz and 390-405 MHz	see 3.1	see 3.1	see 3.1	none	none	none	NIB	For low rate links

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5.2 2025-2110 MHz and 2200-2290 MHz	Low rate with LGA. Higher rate possible with MGA.	LGA does not require pointing. MGA does.	see 3.2	If lander carries S-Band space-Earth equipment, it is possible to modify it to operate at extended frequencies.	If the lander uses S-Band for space-Earth links, there will be self-jamming between the space-Earth and the local links unless there is adequate isolation.	none	Testing in the 2025-2110 MHz band can be coordinated, as it is in SRS E-S band. Testing in the 2290-2300 MHz band is on NIB.	For higher rate link with line of sight.
5.3 2110-2120 MHz and 2290-2300 MHz	see 5.2	see 5.2	see 3.2	If a lander carries an S-Band space-Earth transmitter or receiver, it can be used for local link.	If the lander uses S-Band space-Earth links, there will be self-jamming between the space-Earth and the local links.	A third vehicle using S-Band space-Earth links may interfere with the local link receiver if it is near the local link receiver, or there is not enough antenna discrimination between the Earth link transmitter and the local link receiver.	The 2110-2120 MHz band is already allocated to SRS, deep space, E-to-S. Testing the 2290-2300 MHz is on NIB.	For higher rate link with line of sight.
<b>6.0 Orbit-to-Orbit</b>								
6.1 435-450 MHz and 390-405 MHz	see 3.1	see 3.1	see 3.1	none	none	none	NIB	For low rate links
6.2 2025-2110 MHz and 2200-2290 MHz	see 3.2	see 3.2	see 3.2	If an orbiter uses S-Band space-Earth link, it is possible to modify space-Earth link equipment to operate at extended frequencies.	If an orbiter uses S-Band space-Earth links, there will be self-jamming between the space-Earth and the local links unless there is adequate isolation.	none	Testing in the 2025-2110 MHz band can be coordinated, as it is in SRS E-S band. Testing in the 2290-2300 MHz band is on NIB.	For high rate links. Less likely to share equipment.
6.3 2110-2120 MHz and 2290-2300 MHz	see 3.2	see 3.2	see 3.2	If orbiter carries an S-Band space-Earth link, the local link can share the same equipment.	If one vehicle uses S-Band space-Earth links, there will be self-jamming between the space-Earth and the local links on the vehicle.	see 5.3	The 2110-2120 MHz band is already allocated to SRS, deep space, E-to-S. Testing the 2290-2300 MHz is on NIB.	For high rate links. Can not share equipment with X-Band S-E links.

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6.4 7190-7235 MHz and 8450-8500 MHz	see 3.3	see 3.3	see 3.3	Possible to modify the X-Band space-Earth link equipment to operate in the extended frequency range.	The X-Band transmitter could saturate the X-Band receiver on the same vehicle unless there is adequate isolation.	none	Testing in the 7190-7235 MHz band can be coordinated, as it is in SRS band. Testing in the 8450-8500 MHz band is on NIB.	For high rate links. Possible to share equipment with X-Band S-E link.
<b>7.0 Mars Approach Navigation and Atmosphere Radio Science</b>								
7.1 8400-8450 MHz	Radio metric measurement	Accurate pointing as existing on spacecraft for Earth link.	see 3.3	Sharing equipment with the X-Band S-to-E transmitter	Orbiter doing approach navigation does not operate the Earth link at the same time. Orbiter X-Band S-to-E transmitter will saturate the orbiter local link receiver. However, no simultaneous operation of the Earth link with local link is planned for approach navigation.	Cross Interference will not occur with approach navigation. It may happen with occultation radio science when receiver is in the beam of another orbiter transmitting the S-E link.	NIB	